MASSACHUSETTS COASTAL COMMERCIAL LOBSTER TRAP SAMPLING PROGRAM MAY-NOVEMBER, 1985

Bruce T. Estrella

and

Daniel J. McKiernan

COMMONWEALTH OF MASSACHUSETTS
Department of Fisheries, Wildlife, and
Environmental Law Enforcement
Division of Marine Fisheries
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TABLE OF CONTENTS

ABSTRACT

The fifth consecutive American lobster (Homarus americanus) catch/effort and biological monitoring program was completed in Massachusetts coastal waters in 1985. Six lobstering regions were sampled monthly, during the major lobstering season, May-November. With the cooperation of coastal commercial lobstermen, a total of 35,461 lobster were sampled from 14,132 trap hauls during eighty trips aboard commercial lobster vessels.

Survey catch rate trends continued to parallel lobster landings data for territorial waters. The 1985 coastwide mean catch per trap haul-set-over-day index for marketable lobster (0.286) increased 20% from the 1984 value (0.238). Catch per trap haul indices followed the same trend, representing the highest catch rates of the five year survey period and a record year for lobster catches. Estimates of exploitation rates and total annual mortality remained high. Over 90% of the lobster landed in inshore regions were new recruits (48% east of Cape Cod). The coastwide mean carapace lengths were static at 82 mm, 90 mm, and 76 mm for all lobster, legal, and sublegal size groups, respectively. The percentage of females ovigerous, 8.6, declined from 1984 (9.1%). Approximately 42% of all lobster sampled during 1985 were males compared to 38% during 1983. The percentage of culls increased again to 18.1% from 14.8% in 1984. Trap mortality remained at less than one percent.

A cement gland staging technique was used to establish functional size-maturity relationships for female lobster in five coastal Massachusetts regions. Proportions mature at size represent more realistic values than those obtained by analyses of percent females ovigerous, which underestimate the proportion bearing eggs in the absence of exploitation. Sizes at 50% maturity were: Cape Ann, 90 mm; Boston Harbor, 87 mm; Cape Cod Bay, 87 mm; outer Cape Cod, 97 mm; and Buzzards Bay, 76 mm.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The commercial lobster fishery is the most economically important single-species fishery in Massachusetts coastal waters. For many years this fishery has been monitored by the Massachusetts Division of Marine Fisheries (DMF) Commercial Fisheries Statistics Project. Selected lobster fishery statistics are compiled from catch reports filed annually by lobster license holders. However, coincident with the inception of the State-Federal Lobster Management Program, and ultimately the American Lobster Fishery Management Plan (FMP)[1], the need for a comprehensive, coastwide, organized American lobster management effort was recognized. According to the precepts of the FMP, a long-term statewide monitoring program which would yield biological as well as catch per unit effort data was devised and initiated in Massachusetts in May, 1981. A sea sampling survey design was chosen by which both catch per unit effort and biological data could be collected temporally and areally with sufficient precision for stock assessments. The objective was to assess variations in population parameters due to environmental and/or fishing pressure, or the effects of regulatory changes.

The following report summarizes the data collected during the 1985 coastwide commercial lobster trap sampling program in Massachusetts coastal waters. Parameter trends during the 1981-1985 study period are discussed.

STUDY AREA

The study area is primarily defined by the Massachusetts territorial sea, except where lobstering activities of cooperating commercial lobstermen exceeded territorial boundaries (Figure 1). Territorial waters total 5322 sq. km. (2055 sq. n mi), of which an estimated 60% is considered major lobster habitat. Six sampling regions, Cape Ann, Beverly-Salem, Boston Harbor, Cape Cod Bay, outer Cape Cod, and Buzzards Bay, were chosen for coverage of the major lobstering regions of the state within resources available. For convenience, these regions are depicted as generalized hatchmarked areas wherein lobster gear sampled may be discontinuously distributed.

SAMPLING PROCEDURE

Coverage of coastal waters was accomplished by monitoring catches during the normal lobstering operations of volunteer commercial lobstermen in each designated region. Multiple lobstering operations were observed to reduce bias from varying degrees of lobstering skill and to enhance areal coverage. Five lobstermen were monitored in Gulf of Maine regions, three in the outer

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[1] American Lobster Fishery Management Plan, New England Fishery Management Council, Saugus, Massachusetts, March, 1983.

Cape Cod region and three in Buzzards Bay. Pot-sampling trips were day trips, conducted a minimum of once per month per region (except when manpower limitations precluded effort or cooperating lobstermen were not operating during the major lobstering season, May through November).

Utilizing portable cassette tape recorders, sea samplers recorded carapace length to the nearest mm and to the nearest 0.1 mm between 80.5 and 81.0 mm; sex; and condition, including the degree of shell hardness, culls and other shell damage, external gross pathology, mortality, and presence of extruded ova on females (ovigerous). Catch in number of lobster, number of trap hauls, set-over-days, trap and bait type were also recorded.

ANALYTICAL PROCEDURES

Data were computer coded and keypunched for analysis on the Woods Hole Oceanographic Institution's Digital Equipment Corporation VAX-11/780 computer system. A computer auditing process was used to uncover keypunch and recording errors and statistical analyses were performed with SPSS (Nie 1983) and SAS (SAS Institute 1985) statistical subprograms.

Catch per trap haul-set-over-day (CTHSOD) values were calculated with a different equation [Σ (C/E/T)/N, where C = catch, E = effort, T = soak time, and N = sample size] than was used for previous Massachusetts lobster assessment reports in order to improve confidence limit accuracy and generation. Consequently, CTHSOD rates recalculated for the 1981-1984 period may differ from previously published data; however, the annual trend is unchanged.

The Kolmogorov-Smirnov two-sample test and Mann-Whitney U/Wilcoxon W tests were used to determine the significance of year to year variation in parameters.

Because parameter means exhibit significant regional and monthly variation, an areal and temporal data weighting scheme was incorporated into analytical software. Presently, each month's data contribute equally to regional parameter means which are weighted by area in square nautical miles.

Unless specified otherwise, the terms "legal" or "legal sized" lobster include all lobster in the carapace length category $\geq$ 81 mm. The marketable segment of this category, which excludes ovigerous females, is analyzed separately and is referred to as"marketable lobster". The sublegal length category includes all lobster $<$ 81 mm.

Lobster landings and effort (number of traps) data quoted is derived from lobstermen's catch reports which are compiled annually by the DMF Commercial Fisheries Statistics Project.

Since current management strategy stresses uniform coastwide regulations, all data are grouped for a coastwide analysis. However, the uniqueness of the Massachusetts coastline, its role in providing a temperature barrier

which profoundly affects many marine species (Colton 1964), and the influence of offshore lobster stocks on the inshore resource mandate a regional data treatment as well.

RESULTS AND DISCUSSION

During the period of May through November, 1985, eighty sampling trips were made aboard commercial lobster vessels in Massachusetts coastal waters. A total of 35,461 lobster were sampled from 14,132 trap hauls.

Abundance

The coastwide mean catch per trap haul-set-over-day (CTHSOD) of all lobster sampled in 1985 (0.953) increased from 1984 (0.777) by 23% ($P < 0.001$, Table 1). The catch rate indices for legal sized lobster (0.306) and marketable lobster (0.286) increased by 20% (Tables 2 and 3). The sublegal lobster catch rate (0.648) increased 24% from the 1984 index (0.521, Table 4).

Only Cape Ann and Beverly-Salem CTHSOD indices for all four size groups declined from 1984 to 1985. All other regions exhibited increases.

Catch per trap haul (CTHAUL) of all lobster increased by 22% in 1985 ($P < 0.001$, Table 5). Indices for all lobster $\geq$ 81 mm and marketable lobster increased by 19% and 20%, respectively (Tables 6 and 7); sublegal CTHAUL increased by 23%. Nearly all regional catch rate indices increased from 1984.

The five year trend in catch rates of marketable lobster is similar to the trend in landings from Massachusetts territorial waters which increased to a peak in 1983 followed by a significant decline in 1984 and another peak in 1985 (Figure 2). DMF annual bottom trawl survey CPUE indices (stratified mean catch per tow) from Massachusetts waters for all lobster $\geq$ 81 mm followed a similar trend but exhibited less severe annual amplitude.

The substantial increase in 1985 catch rates and landings represent another record year. Combined offshore and inshore landings totalled 14,315,823 pounds compared to 12,604,065 pounds in 1984. Unusually warm May water temperatures [12.5-13.5 C (54.5-56.3 F) off Boston] initiated molting uncharacteristically early in north shore regions. The resulting exceptional recruitment may have been augmented by lobster which had not molted during spring 1984 when water temperatures were cooler and a recruitment deficit occurred (Estrella 1986). Warm water temperatures not only increase molt frequency, but enhance availability and catch rates by stimulating activity and feeding. Nevertheless, conditions were favorable and the market was flooded for several weeks in July, 1985.

The recruitment of a good year class cannot be discounted as a possible explanation for the 1985 "glut". However, during 1985 the Buzzards Bay catch rate increased from 1984 paralleling catch trends north of Cape Cod. This rarely happens due to differences in recruitment source and local

variation in environmental conditions affecting year-class size, survival, and/or availability. Thus, the hypothesis that optimal conditions for molting were responsible for the higher 1985 catches is more plausible.

Exploitation Rate

Estimated exploitation rates remained high (Table 9). Approximately 87-96% of the lobster landed in inshore regions were captured shortly after molting beyond the legal size limit of 81 mm. This index was 48% for the outer Cape Cod region where a large offshore migrant group dominates catches. The coastwide index was 88%.

No trend in the five year data set was discernible.

Mortality Estimates

Estimates of total instantaneous mortality (Z) and total annual mortality ($A = 1-e^{Z}$) were computed by each of two methods (Table 10). The method of Gulland (1969) requires computing the slope of the regression line of numbers at estimated age (15% molt groups) plotted in the natural log. Beverton and Holt's (1956) process employs Von Bertalanffy Growth Equation parameters (K = 0.0634, L^{∞} = 253 mm; Fair 1977) and mean and minimum length of exploitable sizes:

$$Z = \frac{K(L\infty - \overline{\ell})}{\overline{\ell} - \ell_c}$$

where

K = growth rate constant
L^{∞} = asymptotic length
$\overline{\ell}$ = mean length of exploitable sizes
ℓ_c = minimum exploitable size

Total annual mortality estimates (A) were similar to 1984 estimates ranging from 86% (Z = 1.94, Cape Ann) to 97% (Z = 3.55, Beverly-Salem, Boston Harbor, and Buzzards Bay) in inshore regions and 41% (Z = 0.52) off outer Cape Cod when computed by the method of Gulland (1969). Estimates by the Beverton and Holt (1956) method ranged from 74% (Z = 1.33, Cape Ann) to 91% (Z = 2.36, Buzzards Bay) for inshore regions and 43% (Z = 0.57) off outer Cape Cod.

Mortality estimates over the five-year study period remained relatively stable.

Carapace Length

The mean carapace length of all lobster sampled during 1985 was 81.6 mm which was not significantly different from 1984 (81.7 mm, P = 0.319, Table 11). Lobster $\geq$ 81 mm carapace length averaged 90.1 mm (90.5 mm in 1984, Table 12). Marketable lobster averaged 89.6 mm (90.0 mm in 1984, Table 13) and the mean length of sublegal sized lobster was 76.3 mm (76.1 mm in 1984, Table 14).

The mean carapace length for all lobster ranged from 78.2 mm in the Beverly-Salem region to 82.1 mm off Cape Ann; however, the mean off outer Cape Cod was 95.1 mm (Table 11). The lobster group in this region is seasonally augmented by the shoalwood migration of large offshore lobster. Some offshore influence on Cape Ann lobster is discernible from size frequency analysis (Tables 15-21). The percentage of legal sized lobster which were $\geq$ 100 mm was: Cape Ann, 7.2%; Beverly-Salem, 0.8%; Boston Harbor, 1.2%; Cape Cod Bay, 2.6%; outer Cape Cod, 39.3%; and Buzzards Bay, 0.8%.

The coastwide mean carapace length of marketable lobster varied inversely to the catch rates of this group during the five year study period. This trend is probably due to the recruitment dependency of the fishery. Since most lobster landed are in the recruit molt group (81-93 mm), mean size declines following good recruitment and increases with a recruitment shortfall.

Size frequency data by state and region (Tables 15-21) did not reveal any major distribution changes from 1984.

Maturity

Size at Functional Maturity

The most obvious indication of female lobster maturity is the presence of external eggs on the abdomen. However, analysis of ovigerous female size frequency alone is inadequate to assess reproductive status because of the nature of the ovarian cycle. Females mate primarily within 48 hours following molting, but egg extrusion may occur from a few months to a year later. The harvest of mature yet non-ovigerous and immature females depresses the proportion ovigerous at exploitable sizes and escalates the estimated size at 50% maturity (ovigerous).

The assessment of physiological maturity through ovarian dissection is tedious, time consuming, and requires the sacrifice of many specimens.

A technique developed by Aiken and Waddy (1982) provides an alternative approach to determining size at maturity by estimating functional maturity. This method enables the researcher to predict egg extrusion by assessing the extent of development of the cement glands on the pleopods. Ennis (1984) validated this procedure with a mark-recapture study. The proportion mature at size is higher and more accurate than the observed proportion of females ovigerous.

From 16 May to 16 June, 1986 the cement gland development on 2,536 female lobster was observed in five regions of the state: Cape Ann (N = 634), Boston Harbor (N = 576), Cape Cod Bay (N = 656), outer Cape Cod (N = 367), and Buzzards Bay (N = 303). Due to time constraints, the Beverly-Salem region was not sampled. Pleopods were removed from non-ovigerous females and examined microscopically to stage glandular development. A few specimens with questionable development were dissected and ovary maturation assessed. The proportion mature by 3 mm size groups was calculated (Tables 22-26), analyzed with the non-linear regression procedure ($Y = a/1 + e^{b + cX}$) and graphed in Figures 3-7.

Most lobster in Cape Ann waters matured at sizes larger than the minimum size of 81 mm (Figure 3, Table 22). An estimated 20% of the females at 81 mm carapace length were mature and size at 50% maturity was 90 mm.

Female lobster in Boston Harbor matured earlier than those off Cape Ann (Figure 4, Table 23). However, due to the intense exploitation in this region, very few lobster were available at lengths > 100 mm. The estimated proportion mature at 81 mm was 27% and estimated size at 50% maturity was 87 mm.

Results from the Cape Cod Bay region were similar to the other Gulf of Maine regions (Figure 5, Table 24). The estimated proportion mature at 81 mm was 18% and estimated size at 50% maturity was 87 mm.

Outer Cape Cod lobster matured at much larger sizes than those from Gulf of Maine regions (Figure 6, Table 25). Approximately 12% of the females were mature at 81 mm and estimated size at 50% maturity was 97 mm.

Buzzards Bay lobster matured at the smallest size (Figure 7, Table 26). Seventy-nine percent of the females at 81 mm carapace length were mature and estimated size at 50% maturity was 76 mm.

Maturity estimates in the three Gulf of Maine regions were similar, with Cape Ann females maturing at the largest size (Figure 8). Results from these regions were intermediate compared to those from Buzzards Bay and outer Cape Cod.

Mature sublegal sized females are rare in outer Cape Cod waters in contrast to Buzzards Bay where sublegal sized "eggers" occur frequently. The deeper, colder water environment which is characteristic of Cape Ann and outer Cape Cod is primarily responsible for elevating the size at maturity there. Also, outer Cape Cod lobster are primarily offshore migrants which spend a major portion of each year in a cooler temperature regime.

Morrissey (1975) noted a relationship between environment and size at maturity. Areas where maturity is reached at less than 70 mm are characterized by higher summer temperatures (about 20° C), limited water circulation and exchange, and high population density. However, areas where maturity was not reached until after 85 mm were generally in or adjacent to oceanic waters with relatively low summer temperatures (10° C).

These size at maturity results represent more realistic values than can be estimated from analyses of percent of females ovigerous. Regional sizes at 50% maturity are generally lower than previously reported for other coastal regions in the FMP. Furthermore, previously reported data were based on percent ovigerous and underestimate the proportion which could become ovigerous in the absence of exploitation (i.e., the protection of current legal sizes through a gauge increase). Cement gland maturity data provide a more accurate appraisal of the potential benefits obtained through an increase in the minimum legal size.

Percentage of Females Ovigerous

The coastwide percentage of all females ovigerous was significantly lower in 1985 (8.6) than in 1984 (9.1) ($P < 0.001$, Table 27). The percentage of legal sized females ovigerous (15.0) decreased by 1.2% from 1984 (16.2, Table 28); however, the percentage of sublegal females ovigerous (5.2) was similar to the 1984 index (5.1, Table 29).

Between 1984 and 1985, the percentages of females ovigerous (Table 27) increased off Cape Ann and Beverly Salem, were similar in Cape Cod Bay and Boston Harbor, and declined in the southern regions of outer Cape Cod and Buzzards Bay. The percentages in the latter two regions remained significantly higher than the four Gulf of Maine regions.

Despite small changes, as noted above, the annual values over the 1981-1985 study period were very similar within each region. The four Gulf of Maine regional indices were consistently below 5% with Cape Ann averaging higher than the other regions. The influence of large offshore migrants entering Cape Ann waters may be responsible.

The five year average off outer Cape Cod was 22.7% ovigerous. Although the size at 50% maturity was estimated at 97 mm there, many females reach sexual maturity and extrude eggs prior to being harvested. This is because this lobster group exhibits the lowest exploitation rate (48%) and largest mean carapace length (95.1 mm) among the regions sampled.

As noted above, Cape Ann and outer Cape Cod lobster exhibit a greater offshore population influence. Both Cape Ann and outer Cape Cod are adjacent to steeply sloping gradients which yield to a much wider depth range than is available to the other inshore regions sampled. This may be a factor in concentrating migrants and helps to explain the higher frequency of large egg-bearing females in these regions.

During commercial lobster trap sampling efforts off Cape Ann in 1984 and 1985, 3.4% and 3.3%, respectively, of the legal sized females were V-notched. Off outer Cape Cod, V-notched observations totalled 3.1% and 5.8% of the legal sized females in 1984 and 1985, respectively. All other Massachusetts inshore regions sampled exhibited very low percentages (0 - 0.8). These V-notched females were generally large lobster which averaged 105 mm and 106 mm carapace length (2.1 lbs) in 1984 and 1985, respectively.

The five year average in Buzzards Bay was 23.4% ovigerous. This region is characterized by the highest exploitation rate (96%) and a small average size (78.9 mm). However, as demonstrated by the cement gland staging, 79% of the females were estimated to be mature at 81 mm carapace length. Because there is a theoretical exploitation rate of zero on the sublegal size group, most Buzzards Bay females reach sexual maturity and extrude eggs prior to being harvested.

Carapace Length of Ovigerous Females

The coastwide mean carapace length of all ovigerous females was 87.9 mm which was not significantly different from 1984 (87.4, P = 0.144, Table 30). Small increases were seen in the mean lengths in the four Gulf of Maine regions while the values for the two southernmost regions, Buzzards Bay (80.1) and outer Cape Cod (106.9) decreased slightly. The same trend occurred with "eggers" $\geq$ 81 mm (Table 31).

The mean carapace lengths of "eggers" in the Beverly-Salem, Boston Harbor and Cape Cod Bay regions were similar (85.9, 84.0 and 85.2). This was probably the result of similar sizes at maturity and exploitation rates. These values were slightly lower than the estimated size at 50% maturity (87 mm) for Boston Harbor and Cape Cod Bay.

The mean carapace lengths of "eggers" in the Cape Ann and outer Cape Cod regions remained high (93.8 and 106.9, respectively) due to seasonal infiltration of large offshore berried females and a larger size at maturity in these regions. The Cape Ann and outer Cape Cod values exceeded the estimated sizes at 50% maturity (90 mm and 97 mm, respectively) because of the abundance of large females in these regions.

The mean length of Buzzards Bay ovigerous females was quite low compared to the other five regions. This reflected the small size at maturity but exceeded the size at 50% maturity (76 mm). This may result from trap selectivity; it is likely that a higher proportion of larger sublegals were retained by escape vents.

Mean carapace length of sublegal eggers was 78.1 mm and ranged from 74 mm off outer Cape Cod to 78.8 mm off Cape Ann (Table 32). The relatively small number of sublegal sized eggers sampled (except in Buzzards Bay) and the influence of escape vents and variable soak time on sublegal catches (size frequency) mandate cautious interpretation of these data. However, the five-year coastwide trend in mean carapace length paralleled that for all sublegal lobster and their CTHSOD trend showing increases through 1983, a decline in 1984 and an increase again in 1985.

The percent of ovigerous females $\geq$ 81 mm carapace length was 57.7% (Table 33). Values ranged from 53.8% (1981) to 65.0% (1983) over the five year study period. As previously discussed, Cape Ann (79.0%) and outer Cape Cod (99.9%) exhibited proportionally more legal sized "eggers" than other shoaler coastal regions in 1985 and every other survey year.

Sex Ratio

Females outnumbered males in the catch in 1985 (Table 34), as they have in every year of the survey since 1981. Of all lobster sampled, 41.9% were males, which was significantly higher than the 1984 value (38.0, $P < 0.001$). Similar increases occurred in all regions except Beverly-Salem. Legal and sublegal size categories (45.6% males and 39.6%, respectively) exhibited similar trends (Tables 35 and 36).

Lower proportions of males in the catch of sublegal lobsters may be caused by differential escapement from traps (Estrella and O'Gorman 1983). A majority of females in the legal catch may be attributed to reduced growth rate of females after the onset of sexual maturity and the protection of ovigerous females from exploitation. Saila and Flowers (1965) constructed a model of lobster stock composition and demonstrated these factors to contribute to a higher proportion of females in the legal size category. Briggs and Muschacke (1979) found a higher proportion of females at 30-60 foot depths, while the reverse was true in shoaler waters. Small annual differences in the sex ratio as seen from 1984 to 1985, may be a result of variation in the locations of traps sampled (deep vs. shallow water).

Culls

The percentage of culls among all lobster sampled during 1985 was 18.1% (Table 37). This represented a significant increase from 1984 (14.8%, $P < 0.001$). All regional indices also increased from the previous year. Legal, marketable, and sublegal size categories exhibited similar increases (Tables 38-40).

The five year trend depicts an escalating number of culls in all regions with Buzzards Bay remaining relatively stable. Until 1984, Buzzards Bay exhibited the highest cull rate which was possibly related to its high exploitation rate (highest among coastal Massachusetts regions). In 1984, most regions' cull rates increased substantially while the Buzzards Bay rate remained unchanged.

One possible cause may be enhanced fishing effort from mobile and other fixed gear fisheries. Studies in Connecticut (Smith et al. 1985), Rhode Island (Ganz 1980), and Massachusetts (Currier 1984) indicate that shell damage and cull rate are enhanced by bottom trawl activity, particularly during the molt period. Gill net operations may also be responsible. Such escalated non-trap fishing activity directed at lobster, concurrent with the present decline in finfish resources, is a plausible explanation. However, the increased use of wire mesh lobster traps as well as increased effort in the trap fishery (commercial traps fished, inside 69 W 41 N increased from a reported total 299,368 in 1981 to 371,346 in 1985) should not be discounted as factors enhancing the cull rate. The use of large mesh wire in traps hinders the removal of lobster because it allows them to anchor their claws by grasping the mesh strands. Attempts to remove these lobster may result in autotomy (claw shedding) which may occur immediately or latently. A minimum mesh size of one inch is recommended.

An obvious detrimental effect of culling is the decrease in market value, but culls also retard the growth rate by reducing the size increase at molt and extending the intermolt period. This may cause the culled animal to mature at a smaller than normal size.

Trap Mortality

Percent trap mortality for all lobster sampled during 1985 was 0.18 which did not differ significantly from the 1984 value (0.15, Table 41). Indices for legal and sublegal size groups were also less than one percent (Tables 42-43). Although this parameter may vary seasonally and can be enhanced by environmental stresses, molting, intra- and interspecific aggression during entrapment, pollution, or the synergistic affect of these factors, the five year trend indicates that trap mortality is consistently low and does not represent a problem to the fishery.

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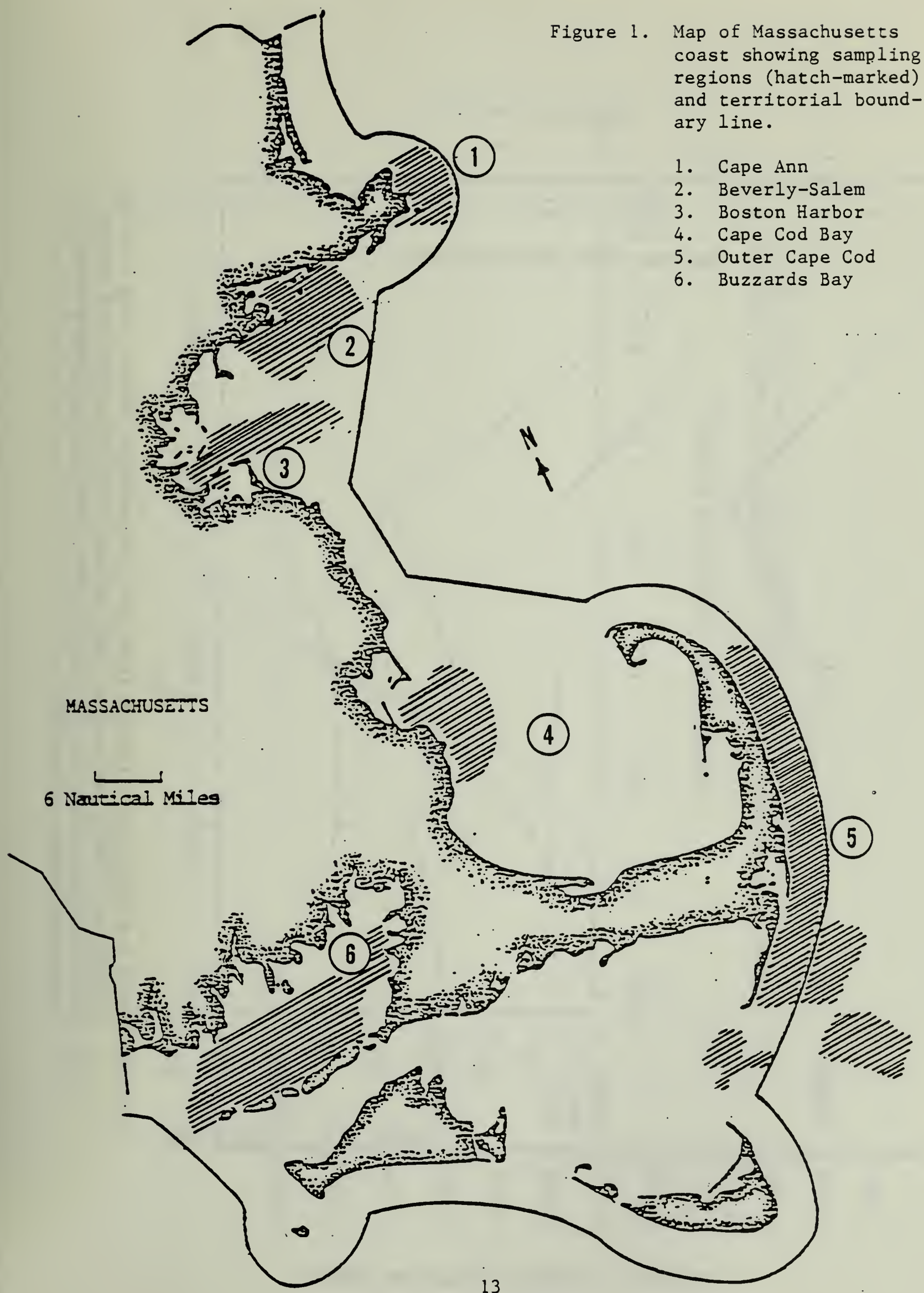

Figure 1. Map of Massachusetts coast showing sampling regions (hatch-marked) and territorial boundary line.

1. Cape Ann
2. Beverly-Salem
3. Boston Harbor
4. Cape Cod Bay
5. Outer Cape Cod
6. Buzzards Bay

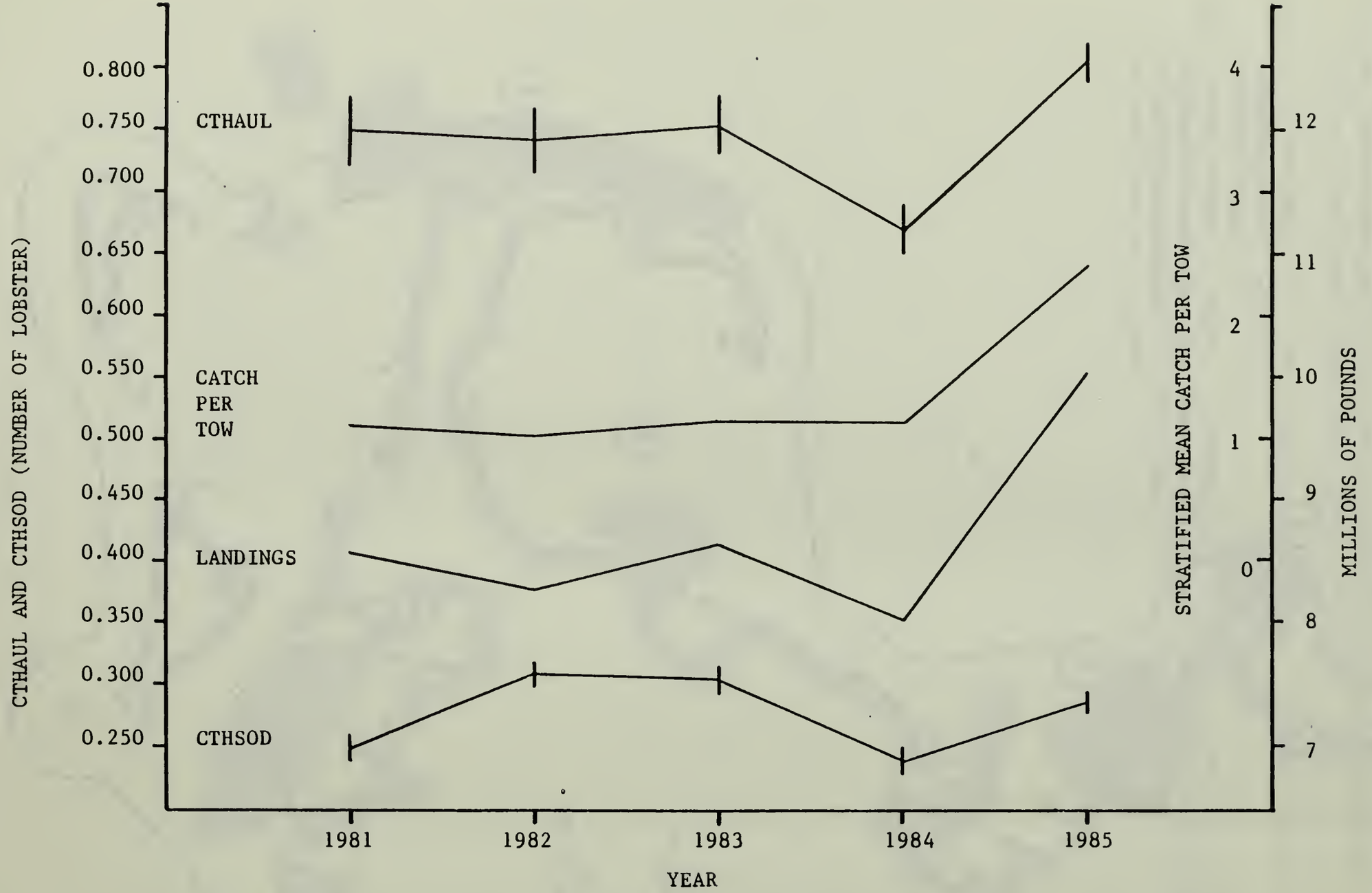

Figure 2. Catch per unit effort indices from coastal commercial lobster trap sampling (CTHAUL and CTHSOD) and bottom trawl surveys (combined spring and autumn stratified mean catch per tow) with lobster landings from Massachusetts territorial waters, 1981-1985.

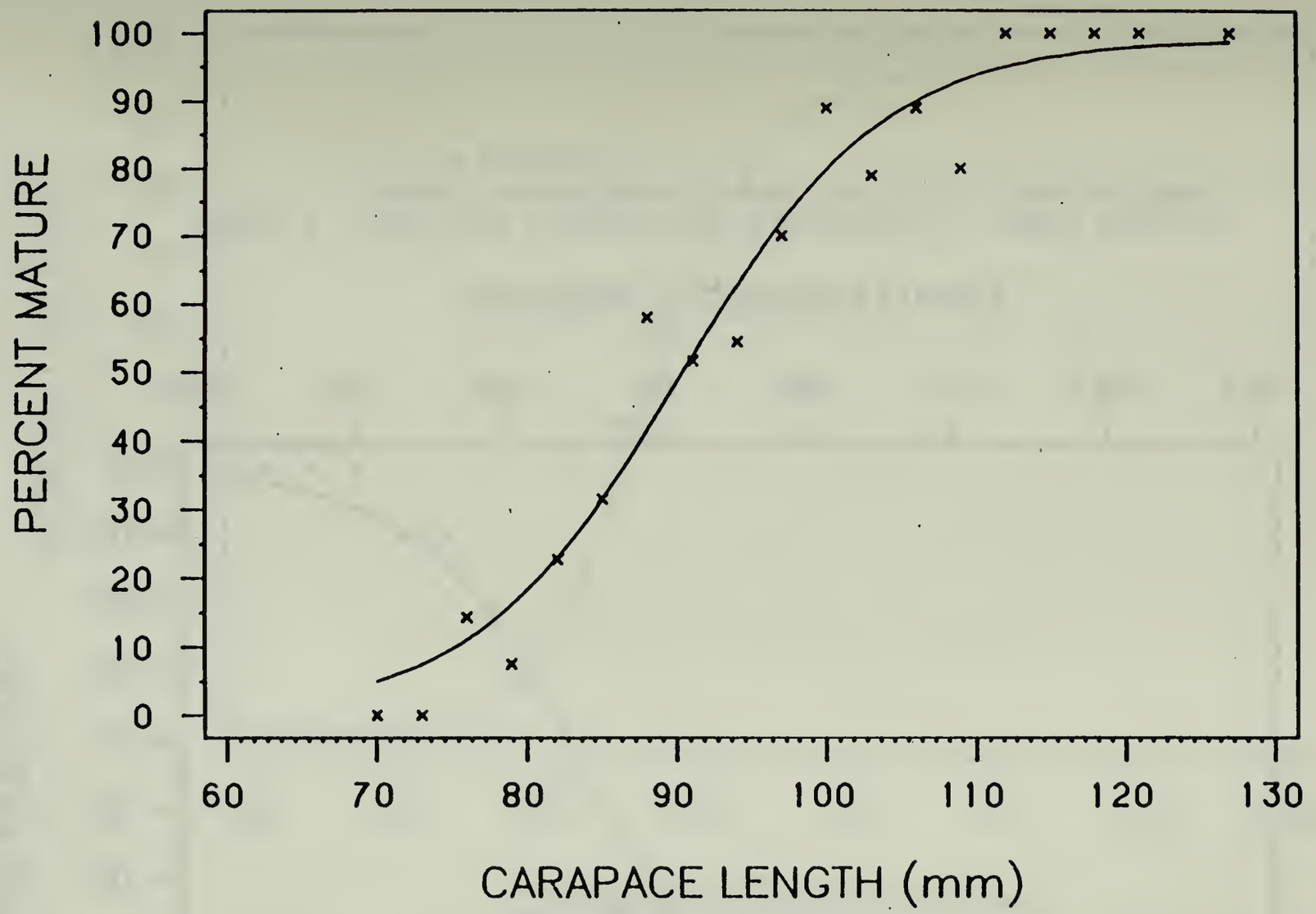

Figure 3. Functional size-maturity relationship for female American lobster, Cape Ann region, 1986 (x's = observed data in 3 mm groupings).

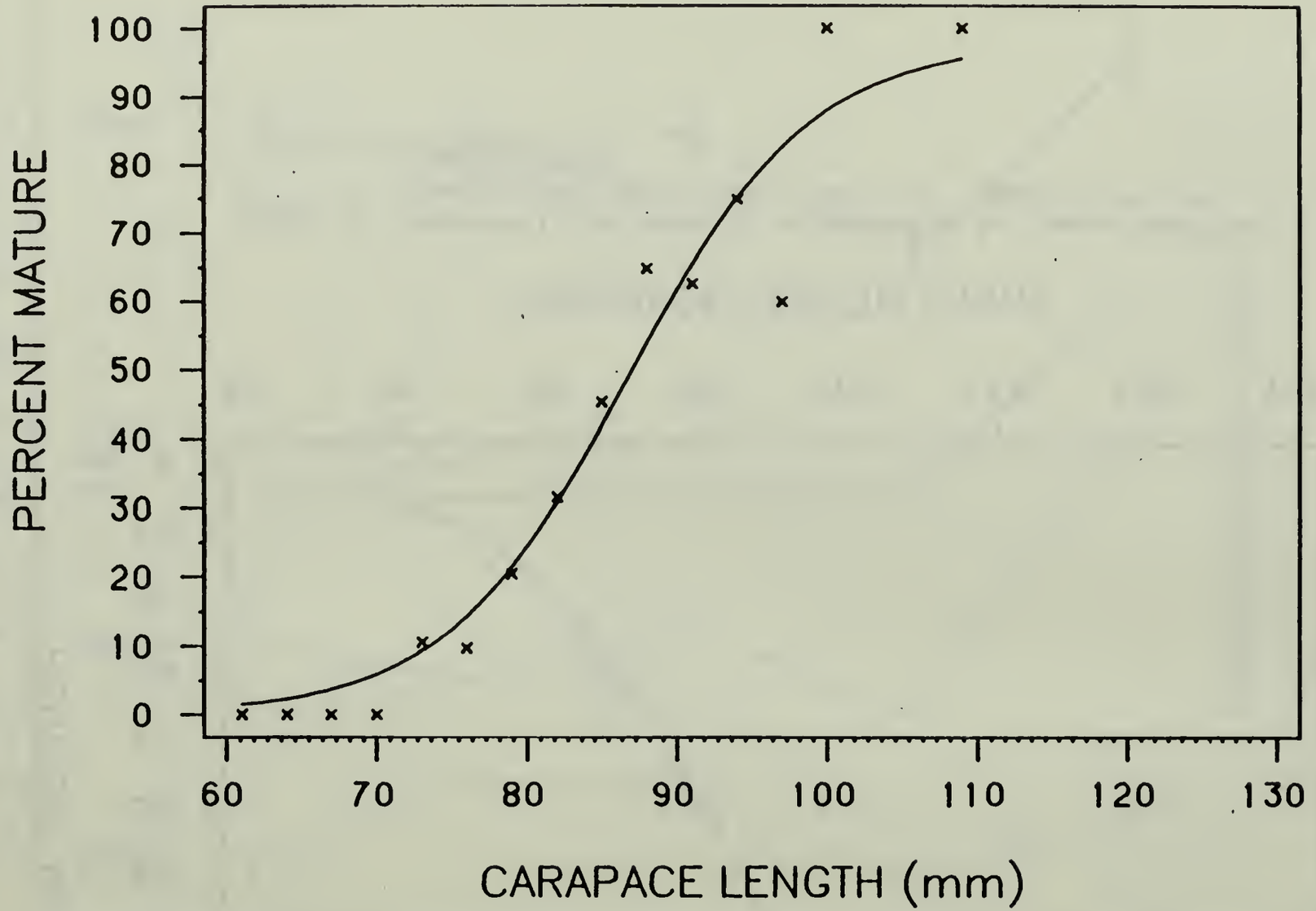

Figure 4. Functional size-maturity relationship for female American lobster, Boston Harbor region, 1986 (x's = observed data in 3 mm groupings).

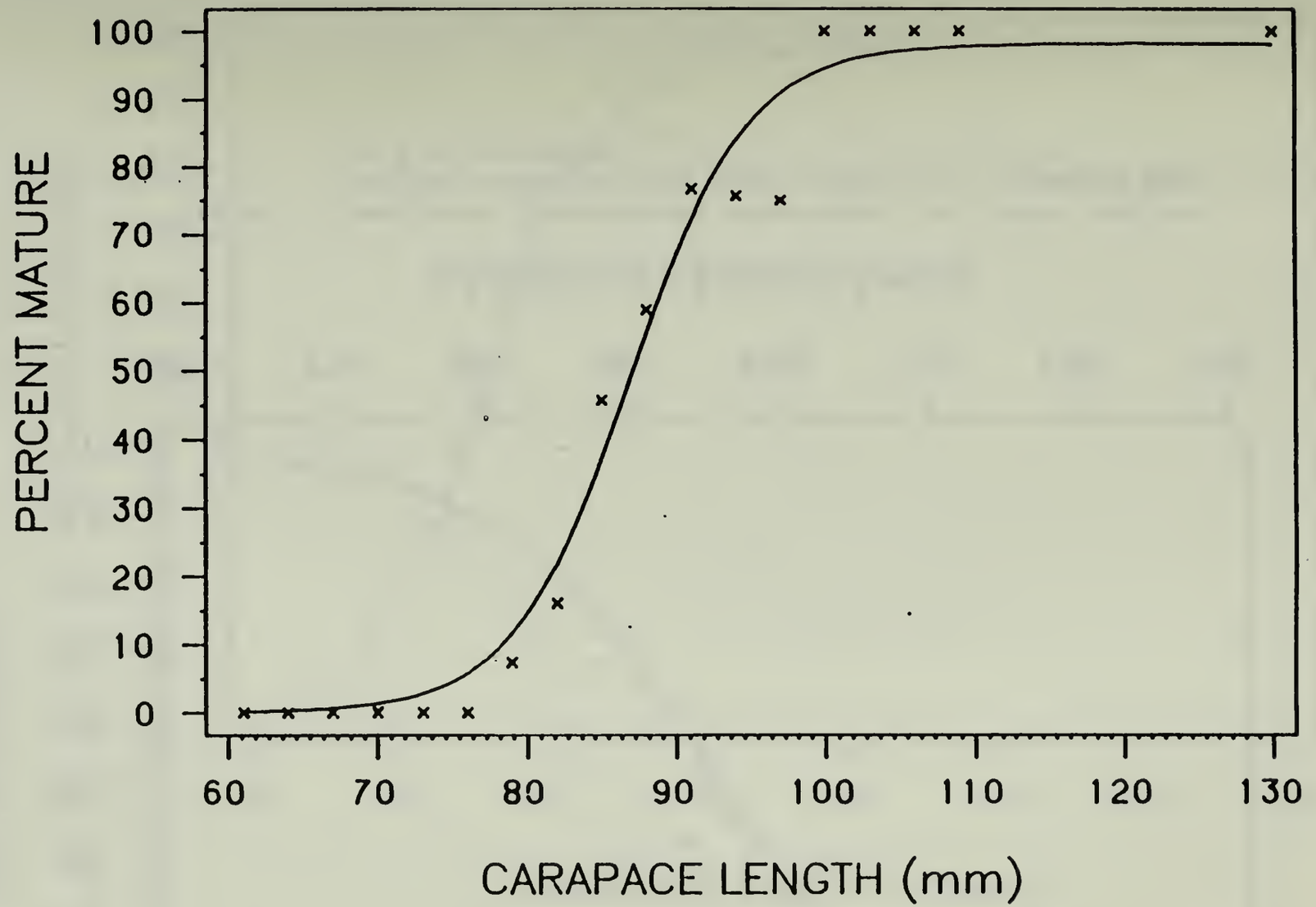

Figure 5. Functional size-maturity relationship for female American lobster, Cape Cod Bay region, 1986 (x's = observed data in 3 mm groupings).

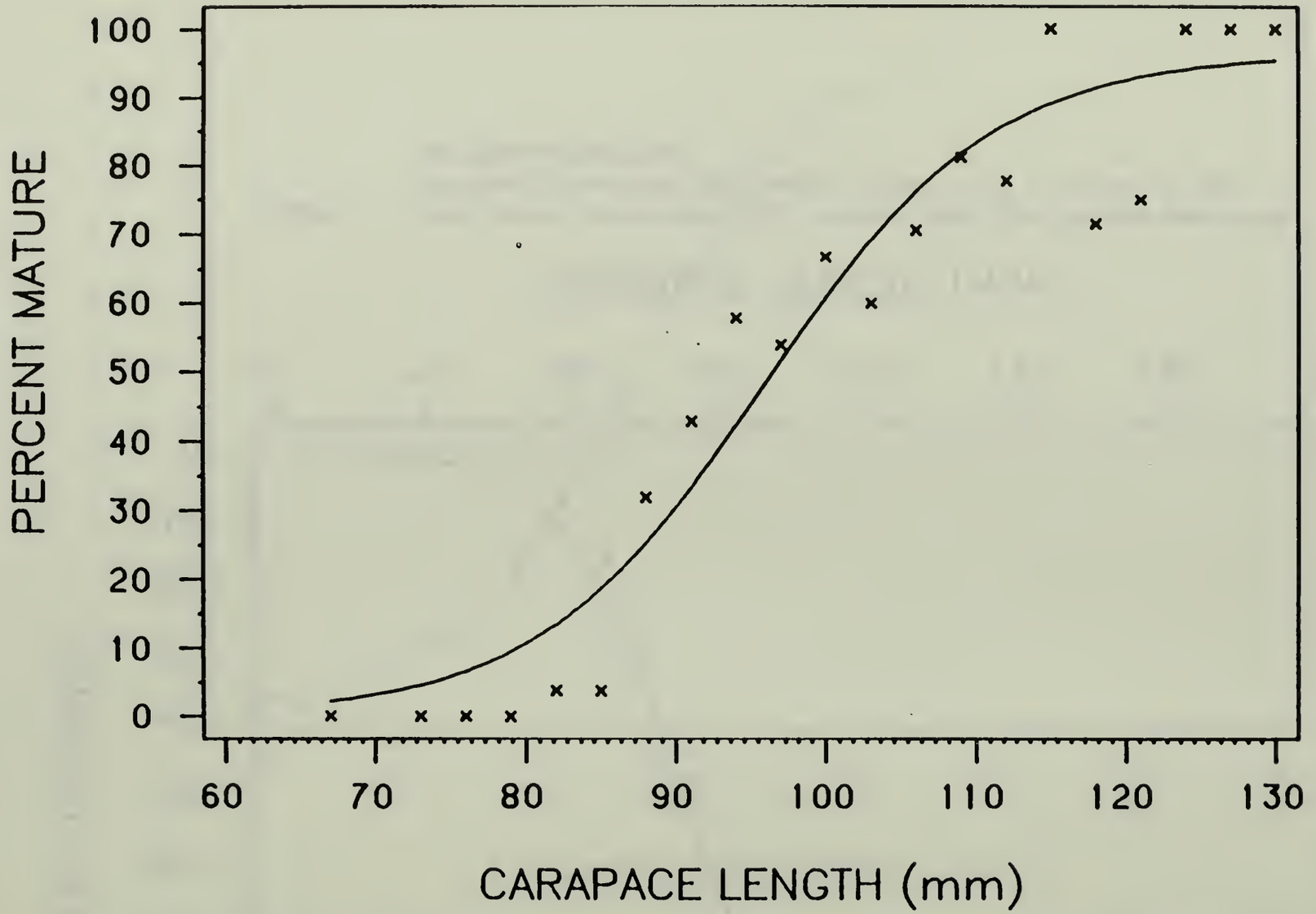

Figure 6. Functional size-maturity relationship for female American lobster, outer Cape Cod region, 1986 (x's = observed data in 3 mm groupings).

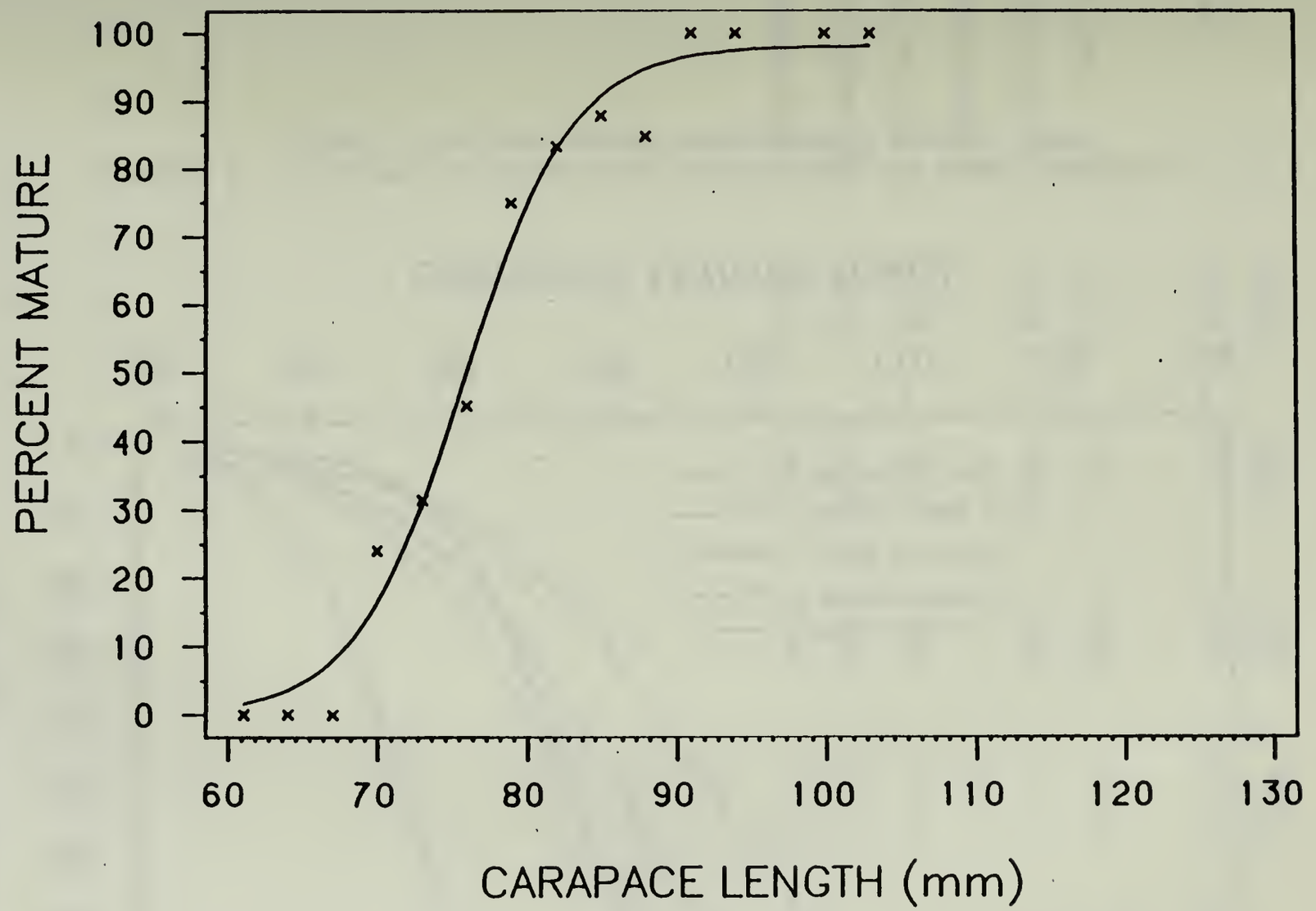

Figure 7. Functional size-maturity relationship for female American lobster, Buzzards Bay region, 1986 (x's = observed data in 3 mm groupings).

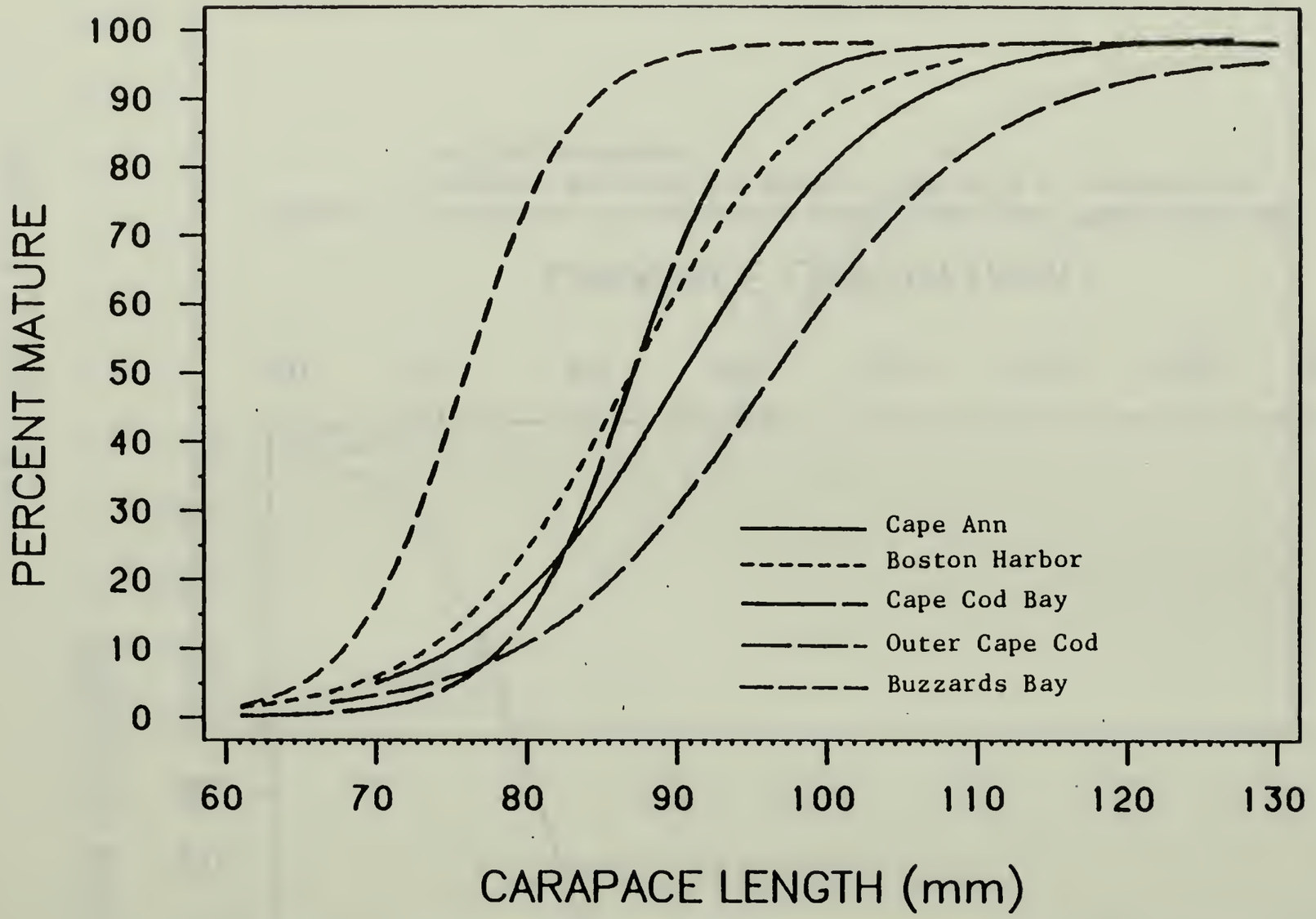

Figure 8. Functional size-maturity relationships for female American lobster from five coastal Massachusetts regions, 1986.

Table 1. CTHSOD by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.838	0.997	1.043	0.777	0.953
Cape Ann	0.251	0.468	0.908	0.751	0.646
Beverly-Salem	1.017	1.084	1.664	1.240	1.084
Boston Harbor	--	--	--	1.267	1.633
Cape Cod Bay	1.008	1.389	0.933	0.506	0.873
Outer Cape Cod	0.175	0.198	0.216	0.176	0.252
Buzzards Bay	1.006	0.849	1.040	1.169	1.236

Table 2. CTHSOD by state and region for all American lobster $\geq$ 81 mm sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.259	0.326	0.325	0.256	0.306
Cape Ann	0.183	0.358	0.322	0.301	0.250
Beverly-Salem	0.310	0.374	0.401	0.292	0.222
Boston Harbor	--	--	--	0.367	0.470
Cape Cod Bay	0.298	0.376	0.293	0.184	0.287
Outer Cape Cod	0.137	0.174	0.178	0.142	0.218
Buzzards Bay	0.219	0.227	0.402	0.382	0.388

Table 3. CTHSOD by state and region for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.249	0.309	0.302	0.238	0.286
Cape Ann	0.181	0.349	0.304	0.289	0.238
Beverly-Salem	0.305	0.368	0.397	0.291	0.215
Boston Harbor	--	--	--	0.362	0.467
Cape Cod Bay	0.287	0.364	0.285	0.178	0.277
Outer Cape Cod	0.125	0.146	0.138	0.113	0.180
Buzzards Bay	0.202	0.190	0.320	0.314	0.327

Table 4. CTHSOD by state and region for all American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.580	0.672	0.718	0.521	0.648
Cape Ann	0.067	0.109	0.586	0.450	0.395
Beverly-Salem	0.708	0.711	1.263	0.948	0.875
Boston Harbor	--	--	--	0.901	1.162
Cape Cod Bay	0.710	1.013	0.639	0.322	0.586
Outer Cape Cod	0.037	0.024	0.383	0.033	0.035
Buzzards Bay	0.787	0.620	0.638	0.785	0.848

Table 5. CTHAUL by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	2.252	2.193	2.466	2.118	2.580
Cape Ann	1.026	0.935	1.578	1.508	1.657
Beverly-Salem	2.749	2.590	3.328	3.286	3.366
Boston Harbor	--	--	--	3.898	4.230
Cape Cod Bay	2.232	2.380	1.984	1.285	2.031
Outer Cape Cod	1.200	1.217	1.262	1.007	1.230
Buzzards Bay	3.044	2.588	3.726	2.980	3.565

Table 6. CTHAUL by state and region for all American lobster ≥ 81 mm sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.779	0.792	0.842	0.728	0.867
Cape Ann	0.769	0.736	0.535	0.598	0.626
Beverly-Salem	0.893	0.878	0.802	0.782	0.702
Boston Harbor	--	--	--	1.125	1.192
Cape Cod Bay	0.687	0.700	0.639	0.461	0.692
Outer Cape Cod	0.968	1.072	1.052	0.818	1.071
Buzzards Bay	0.662	0.668	1.408	1.011	1.114

Table 7. CTHAUL by state and region for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.747	0.740	0.753	0.668	0.802
Cape Ann	0.759	0.723	0.504	0.578	0.596
Beverly-Salem	0.884	0.857	0.793	0.780	0.683
Boston Harbor	--	--	--	1.107	1.181
Cape Cod Bay	0.658	0.677	0.617	0.446	0.668
Outer Cape Cod	0.887	0.896	0.811	0.650	0.896
Buzzards Bay	0.610	0.578	1.116	0.821	0.938

Table 8. CTHAUL by state and region for all American lobster < 81 mm sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	1.473	1.401	1.624	1.389	1.713
Cape Ann	0.256	0.199	1.044	0.909	1.031
Beverly-Salem	1.855	1.713	2.526	2.504	2.664
Boston Harbor	--	--	--	2.773	3.038
Cape Cod Bay	1.544	1.680	1.345	0.825	1.338
Outer Cape Cod	0.233	0.145	0.210	0.189	0.160
Buzzards Bay	2.381	1.916	2.316	1.965	2.452

Table 9. Estimated exploitation rates by state and region, commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	86	86	86	86	88
Cape Ann	91	92	87	89	87
Beverly-Salem	89	92	94	88	96
Boston Harbor	--	--	--	94	94
Cape Cod Bay	90	93	92	94	93
Outer Cape Cod	46	43	42	38	48
Buzzards Bay	98	96	96	94	96

Table 10. Total instantaneous (Z)* and total annual (A)** mortality estimates of American lobster by region, Massachusetts coastal waters, 1981-1985.

	1981		1982		1983		1984		1985	
	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)	Gulland (1969)	Beverton and Holt (1956)
Cape Ann	1.65* 81%**	1.32 73%	2.18 89%	1.39 75%	1.72 82%	1.35. 74%	1.92 85%	1.52 78%	1.94 86%	1.33 74%
Beverly-Salem	1.97 86%	1.59 80%	2.15 88%	1.70 82%	2.41 91%	1.85 84%	2.71 93%	1.78 83%	3.64 97%	1.96 86%
Boston Harbor							2.52 92%	1.82 84%	3.59 97%	1.75 83%
Cape Cod Bay	2.53 92%	1.64 81%	2.69 93%	1.92 85%	2.42 91%	1.72 82%	2.52 92%	2.07 87%	2.31 90%	1.88 85%
Outer Cape Cod	0.43 35%	0.54 42%	0.46 37%	0.55 42%	0.42 34%	0.53 41%	0.33 28%	0.52 41%	0.52 41%	0.57 43%
Buzzards Bay	3.02 95%	2.97 95%	3.00 95%	2.53 92%	8.64 99%	2.26 90%	3.14 96%	2.21 89%	3.55 97%	2.36 91%
Regions combined	1.27 72%	1.07 66%	1.36 74%	1.12 67%	1.32 73%	1.10 67%	1.29 72%	1.15 68%	1.36 74%	1.13 68%

Table 11. Mean carapace length (mm) by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	81.7	82.1	81.7	81.7	81.6
Cape Ann	86.2	86.2	82.1	81.7	82.1
Beverly-Salem	78.2	80.0	77.9	78.3	78.2
Boston Harbor	--	--	--	79.8	79.2
Cape Cod Bay	80.0	79.5	80.0	79.3	79.6
Outer Cape Cod	95.5	96.0	95.9	96.5	95.1
Buzzards Bay	77.8	78.1	80.1	79.6	78.9

Table 12. Mean carapace length (mm) by state and region for all American lobster $\geq$ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	90.6	90.2	90.4	90.5	90.1
Cape Ann	88.9	88.5	88.7	88.2	88.8
Beverly-Salem	87.6	87.2	86.7	86.9	86.4
Boston Harbor	--	--	--	86.9	87.0
Cape Cod Bay	87.4	86.5	87.1	86.2	86.6
Outer Cape Cod	99.1	98.9	99.5	101.1	98.2
Buzzards Bay	84.6	85.2	85.7	85.9	85.5

Table 13. Mean carapace length (mm) by state and region for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	90.2	89.7	89.7	90.0	87.8
Cape Ann	88.6	88.3	88.3	87.9	88.4
Beverly-Salem	87.6	87.0	86.6	86.9	86.2
Boston Harbor	--	--	--	86.8	86.9
Cape Cod Bay	87.2	86.4	86.9	86.1	86.4
Outer Cape Cod	98.2	97.5	97.4	99.7	97.0
Buzzards Bay	84.7	85.2	85.7	85.8	85.2

Table 14. Mean carapace length (mm) by state and region for all American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	75.8	76.3	76.2	76.1	76.3
Cape Ann	78.0	77.7	77.5	77.3	77.6
Beverly-Salem	74.3	76.5	74.9	76.1	75.9
Boston Harbor	--	--	--	77.1	76.9
Cape Cod Bay	76.6	76.4	76.7	75.6	76.1
Outer Cape Cod	75.9	76.2	77.1	75.1	76.6
Buzzards Bay	75.8	75.5	76.8	76.4	76.1

Table 15. Frequency of carapace length observations by number, percent, and cumulative percent, Massachusetts coastal waters, 1985.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
28	1	.0	.0
30	0	.0	.0
38	2	.0	.0
39	2	.0	.0
41	4	.0	.0
42	2	.0	.0
43	1	.0	.0
44	3	.0	.0
45	6	.0	.1
46	10	.0	.1
47	1	.0	.1
48	2	.0	.1
49	7	.0	.1
50	5	.0	.1
51	7	.0	.2
52	6	.0	.2
53	8	.0	.2
54	24	.1	.3
55	18	.1	.3
56	21	.1	.4
57	62	.2	.5
58	48	.1	.7
59	26	.1	.8
60	45	.1	.9
61	55	.2	1.0
62	80	.2	1.3
63	81	.2	1.5
64	96	.3	1.8
65	104	.3	2.1
66	161	.5	2.5
67	130	.4	2.9
68	212	.6	3.5
69	267	.8	4.2
70	345	1.0	5.2
71	407	1.1	6.3
72	597	1.7	8.0
73	747	2.1	10.1
74	1064	3.0	13.1
75	1469	4.1	17.3
76	1999	5.6	22.9
77	2551	7.2	30.1
78	3109	8.8	38.9
79	3573	10.1	49.0

Table 15 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
80	4616	13.0	62.0
81	1281	3.6	65.6
82	1025	2.9	68.5
83	980	2.8	71.2
84	894	2.5	73.8
85	938	2.6	76.4
86	916	2.6	79.0
87	901	2.5	81.5
88	745	2.1	83.6
89	776	2.2	85.8
90	740	2.1	87.9
91	633	1.8	89.7
92	521	1.5	91.2
93	424	1.2	92.4
94	250	.7	93.1
95	242	.7	93.7
96	137	.4	94.1
97	124	.3	94.5
98	104	.3	94.8
99	82	.2	95.0
100	173	.5	95.5
101	103	.3	95.8
102	60	.2	96.0
103	119	.3	96.3
104	67	.2	96.5
105	127	.4	96.8
106	52	.1	97.0
107	97	.3	97.3
108	81	.2	97.5
109	66	.2	97.7
110	99	.3	98.0
111	55	.2	98.1
112	47	.1	98.2
113	43	.1	98.4
114	33	.1	98.5
115	62	.2	98.6
116	35	.1	98.7
117	48	.1	98.9
118	23	.1	98.9
119	27	.1	99.0
120	40	.1	99.1
121	30	.1	99.2
122	28	.1	99.3
123	44	.1	99.4
124	19	.1	99.5
125	16	.0	99.5

Table 15 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
126	24	.1	99.6
127	9	.0	99.6
128	17	.0	99.6
129	9	.0	99.7
130	11	.0	99.7
131	6	.0	99.7
132	23	.1	99.8
133	1	.0	99.8
134	10	.0	99.8
135	22	.1	99.9
136	12	.0	99.9
137	7	.0	99.9
138	1	.0	99.9
139	5	.0	99.9
140	5	.0	100.0
141	1	.0	100.0
142	3	.0	100.0
145	1	.0	100.0
149	2	.0	100.0
150	2	.0	100.0
151	1	.0	100.0
154	1	.0	100.0
158	1	.0	100.0
Total	35461	100.0	

Table 16. Frequency of carapace length observations by numbers, percent, and cumulative percent for the Cape Ann region, Massachusetts coastal waters, 1985.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
51	2	.0	.0
53	2	.0	.1
54	1	.0	.1
57	1	.0	.1
59	1	.0	.1
60	3	.1	.2
61	3	.1	.2
63	3	.1	.3
64	3	.0	.3
65	5	.1	.5
66	12	.2	.7
67	6	.1	.8
68	14	.3	1.1
69	18	.3	1.4
70	22	.4	1.8
71	27	.5	2.3
72	43	.8	3.1
73	50	.9	4.1
74	94	1.8	5.9
75	161	3.0	8.9
76	272	5.1	14.0
77	380	7.2	21.2
78	544	10.3	31.5
79	573	10.8	42.3
80	921	17.4	59.7
81	106	2.0	61.7
82	116	2.2	63.9
83	137	2.6	66.5
84	140	2.7	69.1
85	162	3.1	72.2
86	200	3.8	75.9
87	166	3.1	79.1
88	180	3.4	82.5
89	182	3.4	85.9
90	142	2.7	88.6
91	145	2.7	91.3
92	102	1.9	93.3
93	76	1.4	94.7
94	39	.7	95.4
95	30	.6	96.0
96	22	.4	96.4
97	10	.2	96.6
98	12	.2	96.8
99	15	.3	97.1

Table 16 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
100	14	.3	97.4
101	23	.4	97.8
102	16	.3	98.1
103	10	.2	98.3
104	7	.1	98.4
105	12	.2	98.7
106	16	.3	99.0
107	10	.2	99.1
108	5	.1	99.2
109	6	.1	99.3
110	3	.0	99.4
111	3	.1	99.5
112	4	.1	99.5
113	1	.0	99.6
114	3	.1	99.6
115	3	.1	99.7
116	2	.0	99.7
117	4	.1	99.8
118	2	.0	99.8
119	2	.0	99.9
120	2	.0	99.9
121	1	.0	99.9
122	1	.0	99.9
123	1	.0	100.0
128	2	.0	100.0
137	1	.0	100.0
Total	5296	100.0	

Table 17. Frequency of carapace length observations by numbers, percent and cumulative percent for the Beverly-Salem region, Massachusetts coastal waters, 1985.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
38	1	.0	.0
39	1	.0	.0
41	4	.1	.1
43	1	.0	.1
44	5	.1	.2
45	5	.1	.2
46	1	.0	.2
48	3	.0	.3
49	6	.1	.4
50	1	.0	.4
51	2	.0	.4
52	3	.0	.5
53	1	.0	.5
54	5	.1	.5
55	2	.0	.6
56	5	.1	.6
57	3	.0	.7
58	7	.1	.8
59	7	.1	.9
60	13	.2	1.1
61	24	.3	1.4
62	17	.2	1.7
63	29	.4	2.1
64	20	.3	2.3
65	35	.5	2.8
66	39	.5	3.4
67	47	.7	4.1
68	80	1.1	5.2
69	89	1.3	6.5
70	135	1.9	8.4
71	114	1.6	10.0
72	165	2.4	12.4
73	235	3.3	15.7
74	301	4.3	20.0
75	377	5.4	25.4
76	485	6.9	32.3
77	665	9.5	41.8
78	784	11.2	52.9
79	750	10.7	63.6
80	1054	15.0	78.7
81	147	2.1	80.8
82	151	2.1	82.9

Table 17 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
83	116	1.7	84.6
84	145	2.1	86.6
85	133	1.9	88.5
86	120	1.7	90.2
87	145	2.1	92.3
88	123	1.8	94.0
89	109	1.6	95.6
90	72	1.0	96.6
91	97	1.4	98.0
92	44	.6	98.6
93	43	.6	99.2
94	11	.2	99.4
95	7	.1	99.5
96	2	.0	99.5
97	7	.1	99.6
98	4	.1	99.7
99	10	.1	99.8
100	4	.1	99.9
101	1	.0	99.9
102	1	.0	99.9
104	1	.0	99.9
105	2	.0	100.0
107	1	.0	100.0
114	1	.0	100.0
136	1	.0	100.0
Total	7018	100.0	

Table 18. Frequency of carapace length observations by number, percent, and cumulative percent for the Boston Harbor region, Massachusetts coastal waters, 1985.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
30	1	.0	.0
46	2	.0	.0
48	1	.0	.0
50	3	.0	.1
53	3	.0	.1
55	2	.0	.1
56	2	.0	.1
57	2	.0	.2
58	8	.1	.2
59	7	.1	.3
60	6	.1	.4
61	5	.0	.4
62	4	.0	.5
63	7	.1	.5
64	15	.2	.7
65	16	.2	.8
66	30	.3	1.1
67	19	.2	1.3
68	31	.3	1.6
69	45	.4	2.1
70	69	.7	2.8
71	108	1.1	3.8
72	197	2.0	5.8
73	246	2.4	8.2
74	388	3.9	12.1
75	547	5.4	17.5
76	739	7.3	24.9
77	997	9.9	34.8
78	1072	10.6	45.4
79	1212	12.0	57.5
80	1466	14.6	72.0
81	192	1.9	73.9
82	257	2.6	76.5
83	222	2.2	78.7
84	250	2.5	81.2
85	243	2.4	83.6
86	234	2.3	85.9
87	268	2.7	88.6
88	211	2.1	90.7
89	185	1.8	92.5
90	181	1.8	94.3
91	161	1.6	95.9

Table 18 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
92	139	1.4	97.3
93	86	.9	98.1
94	70	.7	98.8
95	30	.3	99.1
96	26	.3	99.4
97	16	.2	99.5
98	8	.1	99.6
99	6	.1	99.7
100	6	.1	99.7
101	4	.0	99.8
102	4	.0	99.8
103	5	.1	99.9
104	4	.0	99.9
106	3	.0	99.9
107	2	.0	99.9
108	1	.0	100.0
109	1	.0	100.0
112	1	.0	100.0
128	1	.0	100.0
136	1	.0	100.0
Total	10065	100.0	

Table 19. Frequency of carapace length observations by number, percent, and cumulative percent for the Cape Cod Bay region, Massachusetts coastal waters, 1985.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
38	1	.0	.0
39	1	.0	.0
41	1	.0	.0
42	1	.0	.0
45	1	.0	.1
46	3	.0	.1
47	1	.0	.1
49	2	.0	.2
50	2	.0	.2
51	2	.0	.2
52	2	.0	.2
53	2	.0	.3
54	8	.1	.4
55	7	.1	.5
56	8	.1	.6
57	28	.4	1.0
58	17	.3	1.3
59	7	.1	1.4
60	11	.2	1.5
61	16	.2	1.8
62	24	.3	2.1
63	22	.3	2.4
64	23	.3	2.8
65	23	.3	3.1
66	48	.7	3.8
67	28	.4	4.2
68	52	.8	5.0
69	64	.9	5.9
70	54	.8	6.7
71	81	1.2	7.9
72	118	1.7	9.6
73	131	1.9	11.5
74	198	2.9	14.4
75	238	3.5	17.9
76	416	6.1	23.9
77	519	7.6	31.5
78	639	9.3	40.8
79	830	12.1	52.9
80	933	13.6	66.5
81	369	5.4	71.9
82	240	3.5	75.4
83	195	2.8	78.2
84	163	2.4	80.6

Table 19 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
85	149	2.2	82.8
86	159	2.3	85.1
87	180	2.6	87.7
88	125	1.8	89.5
89	162	2.4	91.9
90	97	1.4	93.3
91	113	1.6	94.9
92	102	1.5	96.4
93	80	1.2	97.6
94	42	.6	98.2
95	25	.4	98.6
96	18	.3	98.8
97	10	.2	99.0
98	7	.1	99.1
99	3	.0	99.1
100	8	.1	99.3
101	6	.1	99.3
102	3	.0	99.4
103	6	.1	99.5
104	7	.1	99.6
105	1	.0	99.6
107	5	.1	99.7
108	3	.0	99.7
109	8	.1	99.8
110	1	.0	99.8
111	3	.1	99.9
112	4	.1	99.9
114	1	.0	99.9
116	1	.0	99.9
120	3	.0	100.0
Total	6861	100.0	

Table 20. Frequency of carapace length observations by number, percent, and cumulative percent for the outer Cape Cod region, Massachusetts coastal waters, 1985.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
52	1	.0	.0
54	2	.1	.1
57	2	.1	.2
58	2	.1	.3
60	1	.0	.4
62	6	.3	.7
63	1	.0	.7
64	4	.2	.9
67	2	.1	1.0
68	1	.1	1.1
69	1	.1	1.1
70	1	.1	1.2
71	5	.2	1.4
72	5	.2	1.7
73	8	.4	2.1
74	5	.2	2.3
75	21	1.0	3.3
76	19	.9	4.2
77	30	1.5	5.7
78	44	2.1	7.8
79	47	2.3	10.1
80	90	4.4	14.5
81	50	2.4	16.9
82	47	2.3	19.1
83	66	3.2	22.3
84	47	2.3	24.6
85	77	3.7	28.4
86	72	3.5	31.9
87	57	2.7	34.6
88	54	2.6	37.2
89	56	2.7	39.9
90	109	5.3	45.2
91	73	3.6	48.8
92	66	3.2	52.0
93	64	3.1	55.1
94	40	2.0	57.1
95	63	3.1	60.1
96	32	1.5	61.7
97	37	1.8	63.5
98	34	1.7	65.1
99	26	1.2	66.4
100	64	3.1	69.5
101	33	1.6	71.1
102	19	.9	72.0

Table 20 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
103	43	2.1	74.1
104	21	1.0	75.1
105	53	2.6	77.7
106	18	.9	78.6
107	36	1.8	80.3
108	32	1.6	81.9
109	22	1.1	83.0
110	43	2.1	85.1
111	21	1.0	86.1
112	17	.8	86.9
113	19	.9	87.8
114	14	.7	88.4
115	27	1.3	89.8
116	15	.7	90.5
117	21	1.0	91.5
118	10	.5	92.0
119	12	.6	92.5
120	15	.7	93.3
121	13	.7	93.9
122	12	.6	94.5
123	20	1.0	95.4
124	8	.4	95.8
125	7	.3	96.2
126	11	.5	96.7
127	4	.2	96.9
128	7	.3	97.3
129	4	.2	97.5
130	5	.2	97.7
131	3	.1	97.8
132	11	.5	98.4
133	1	.0	98.4
134	4	.2	98.6
135	10	.5	99.1
136	5	.2	99.3
137	3	.2	99.5
138	1	.0	99.5
139	2	.1	99.6
140	2	.1	99.7
141	1	.0	99.7
142	2	.1	99.8
145	1	.0	99.8
149	1	.0	99.9
150	1	.0	99.9
151	1	.0	100.0
154	1	.0	100.0
158	1	.0	100.0
Total	2062	100.0	

Table 21. Frequency of carapace length observations by number, percent, and cumulative percent for the Buzzards Bay region, Massachusetts coastal waters, 1985.

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
28	1	.0	.0
46	1	.0	.1
55	1	.0	.1
56	1	.0	.1
58	1	.0	.1
59	2	.1	.2
60	7	.2	.3
61	4	.1	.4
62	5	.1	.6
63	10	.2	.8
64	16	.4	1.2
65	20	.5	1.7
66	16	.4	2.1
67	22	.5	2.6
68	27	.7	3.2
69	39	.9	4.2
70	82	2.0	6.1
71	77	1.8	8.0
72	104	2.5	10.5
73	140	3.4	13.9
74	188	4.5	18.4
75	290	7.0	25.4
76	263	6.3	31.7
77	287	6.9	38.6
78	358	8.6	47.1
79	376	9.0	56.2
80	559	13.4	69.6
81	160	3.9	73.5
82	133	3.2	76.7
83	155	3.7	80.4
84	143	3.4	83.8
85	146	3.5	87.3
86	115	2.8	90.1
87	89	2.1	92.2
88	79	1.9	94.1
89	60	1.4	95.6
90	77	1.9	97.4
91	25	.6	98.0
92	20	.5	98.5
93	12	.3	98.8
94	13	.3	99.1
95	14	.3	99.4

Table 21 (continued).

CARAPACE LENGTH (mm)	NUMBER	PERCENT	CUMULATIVE PERCENT
96	5	.1	99.6
97	4	.1	99.7
98	2	.1	99.7
99	2	.0	99.8
100	2	.1	99.8
101	1	.0	99.8
102	1	.0	99.9
103	3	.1	99.9
104	1	.0	100.0
106	1	.0	100.0
111	1	.0	100.0
Total	4159	100.0	

Table 22. Observed and predicted estimates of female American lobster maturity by carapace length, Cape Ann region, 1986 (3 mm groupings of observed data were tabulated at their midpoints).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
69	0	1	-	4.3
70	0	3	0.0	4.9
71	0	3	-	5.7
72	0	3	-	6.5
73	0	5	0.0	7.4
74	0	6	-	8.5
75	1	6	-	9.7
76	2	10	14.3	11.0
77	0	5	-	12.6
78	0	11	-	14.2
79	0	14	7.5	16.1
80	3	15	-	18.2
81	4	25	-	20.4
82	3	21	22.6	22.9
83	12	38	-	25.6
84	7	38	-	28.4
85	9	25	31.5	31.5
86	19	48	-	34.7
87	17	32	-	38.0
88	22	43	58.0	41.5
89	30	44	-	45.0
90	18	42	-	48.6
91	19	34	51.5	52.2
92	13	21	-	55.8
93	9	17	-	59.3
94	11	18	54.3	62.7
95	5	11	-	66.0
96	3	4	-	69.1
97	6	10	70.0	72.1
98	5	6	-	74.9
99	5	5	-	77.4
100	7	9	88.9	79.8
101	4	4	-	82.0
102	6	7	-	83.9
103	5	5	78.9	85.7
104	4	7	-	87.3
105	2	3	-	88.7
106	6	7	88.9	90.0
107	8	8	-	91.2
108	2	2	-	92.2
109	2	3	80.0	93.0
111	4	4	-	94.5

Table 22 (continued).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
112	3	3	100.0	95.1
113	3	3	-	95.6
115	-	-	100.0	96.5
116	1	1	-	96.8
117	2	2	-	97.1
118	-	-	100.0	97.4
121	1	1	100.0	98.0
127	-	-	100.0	98.7
128	1	1	-	98.7

Table 23. Observed and predicted estimates of female American lobster maturity by carapace length, Boston Harbor region, 1986 (3 mm groupings of observed data were tabulated at their midpoints).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
61	-	-	0.0	1.4
62	0	1	-	1.7
64	0	1	0.0	2.3
66	0	2	-	3.1
67	0	3	0.0	3.7
68	0	1	-	4.3
69	0	1	-	5.0
70	0	3	0.0	5.9
72	0	3	-	8.0
73	0	8	10.5	9.3
74	2	8	-	10.7
75	0	9	-	12.4
76	4	31	9.7	14.3
77	3	32	-	16.4
78	9	43	-	18.8
79	11	47	20.4	21.4
80	12	67	-	24.3
81	9	45	-	27.4
82	7	22	31.6	30.8
83	10	20	-	34.3
84	5	21	-	38.1
85	11	25	45.3	42.0
86	14	18	-	46.0
87	10	18	-	50.0
88	18	27	64.8	54.0
89	12	20	-	57.9
90	9	14	-	61.8
91	6	10	62.5	65.4
92	1	3	-	68.9
93	2	4	-	72.2
94	2	2	75.0	75.2
95	1	1	-	77.9
96	1	2	-	80.4
97	-	-	60.0	82.7
98	2	3	-	84.7
100	1	1	100.0	88.1
108	1	1	-	95.2
109	-	-	100.0	95.6

Table 24. Observed and predicted estimates of female American lobster maturity by carapace length, Cape Cod Bay region, 1986 (3 mm groupings of observed data were tabulated at their midpoints).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
46	-	-	0.0	0.0
47	0	1	-	0.0
48	0	2	-	0.0
49	-	-	0.0	0.0
50	0	1	-	0.0
52	-	-	0.0	0.0
53	0	1	-	0.0
55	0	1	0.0	0.0
56	0	3	-	0.0
58	0	1	0.0	0.1
59	0	1	-	0.1
60	0	2	-	0.1
61	0	2	0.0	0.1
62	0	4	-	0.2
63	0	3	-	0.2
64	0	2	0.0	0.3
65	0	1	-	0.4
66	0	2	-	0.5
67	0	2	0.0	0.6
68	0	2	-	0.8
69	0	1	-	1.0
70	0	3	0.0	1.3
71	0	4	-	1.7
72	0	2	-	2.2
73	0	9	0.0	2.8
74	0	13	-	3.6
75	0	17	-	4.5
76	0	16	0.0	5.8
77	0	15	-	7.3
78	0	20	-	9.2
79	0	15	7.3	11.6
80	4	20	-	14.4
81	4	32	-	17.8
82	6	30	16.0	21.8
83	5	32	-	26.4
84	15	42	-	31.5
85	23	45	15.6	37.2
86	19	38	-	43.2
87	18	32	-	49.4
88	21	35	59.0	55.5
89	20	33	-	61.5
90	26	35	-	67.1
91	28	36	76.7	72.2

Table 24 (continued).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
92	25	32	-	76.7
93	18	23	-	80.6
94	11	16	75.6	84.0
95	5	6	-	86.8
96	6	7	-	89.1
97	1	2	75.0	90.9
98	2	3	-	92.4
99	3	3	-	93.6
100	-	-	100.0	94.6
101	1	1	-	95.3
102	1	1	-	95.9
103	2	2	100.0	96.4
105	1	1	-	97.0
106	1	1	100.0	97.3
109	-	-	100.0	97.7
110	1	1	-	97.8
130	-	-	100.0	98.0
131	1	1	-	98.0

Table 25. Observed and predicted estimates of female American lobster maturity by carapace length, outer Cape Cod region, 1986 (3 mm groupings were tabulated at their midpoints).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
66	0	1	-	1.9
67	-	-	0.0	2.1
68	0	1	-	2.4
73	-	-	0.0	4.6
74	0	1	-	5.2
75	0	2	-	5.8
76	0	2	0.0	6.6
78	0	2	-	8.4
79	0	2	0.0	9.5
80	0	3	-	10.6
81	0	13	-	12.0
82	2	18	3.7	13.4
83	0	23	-	15.0
84	0	16	-	16.7
85	2	21	3.7	18.6
86	0	17	-	20.7
87	3	15	-	22.9
88	4	14	31.8	25.2
89	7	15	-	27.7
90	7	16	-	30.4
91	5	10	42.9	33.2
92	9	23	-	36.1
93	5	8	-	39.1
94	6	11	57.7	42.2
95	4	7	-	45.3
96	1	3	-	48.5
97	1	4	53.8	51.7
98	5	6	-	54.8
99	3	7	-	57.9
100	4	4	66.7	60.9
101	5	7	-	63.8
102	4	8	-	66.5
103	3	3	60.0	69.2
104	5	9	-	71.7
105	4	4	-	74.0
106	2	4	70.6	76.2
107	6	9	-	78.2
108	7	7	-	80.1
109	5	7	81.3	81.8
110	1	2	-	83.4
112	4	5	77.8	86.1
113	3	4	-	87.2
115	3	3	100.0	89.2

Table 25 (continued).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
116	1	1	-	90.1
117	2	3	-	90.8
118	2	2	71.4	91.5
119	1	2	-	92.1
120	0	1	-	92.6
121	2	2	75.0	93.1
122	1	1	-	93.5
124	1	1	100.0	94.2
127	3	3	100.0	94.9
128	2	2	-	95.1
130	-	-	100.0	95.4
131	2	2	-	95.6
132	1	1	-	95.7
133	2	2	100.0	95.8
136	2	2	100.0	96.0
138	1	1	-	96.1
139	2	2	100.0	96.2
142	-	-	100.0	96.3
143	1	1	-	96.3
144	1	1	-	96.4
145	-	-	100.0	96.4

Table 26. Observed and predicted estimates of female American lobster maturity by carapace length, Buzzards Bay region, 1986 (3 mm groupings were tabulated at their midpoints).

CARAPACE LENGTH (mm)	NUMBER MATURE	NUMBER SAMPLED	% MATURE OBSERVED	% MATURE PREDICTED
60	0	2	-	1.2
61	0	1	0.0	1.6
62	0	1	-	2.1
63	0	4	-	2.8
64	0	1	0.0	3.7
65	0	4	-	4.8
66	0	5	-	6.2
67	0	1	0.0	8.0
68	0	10	-	10.2
69	0	3	-	13.0
70	2	10	24.0	16.4
71	4	12	-	20.5
72	1	11	-	25.4
73	7	15	31.4	30.9
74	3	9	-	36.9
75	3	9	-	43.4
76	5	10	45.2	50.2
77	6	12	-	56.8
78	8	11	-	63.2
79	7	11	75.0	69.1
80	12	14	-	74.4
81	14	18	-	79.0
82	12	16	83.3	82.9
83	19	20	-	86.1
84	10	12	-	88.7
85	14	15	87.8	90.8
86	12	14	-	92.5
87	6	8	-	93.8
88	8	11	84.8	94.8
89	14	14	-	95.6
90	7	7	-	96.2
91	6	6	100.0	96.6
92	1	1	-	97.0
94	2	2	100.0	97.5
100	2	2	100.0	98.0
103	1	1	100.0	98.1

Table 27. Percent of females ovigerous by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	5.9	7.7	10.9	9.1	8.6
Cape Ann	1.7	3.1	4.4	3.2	4.6
Beverly-Salem	1.7	2.8	1.2	0.4	1.9
Boston Harbor	--	--	--	1.4	1.2
Cape Cod Bay	3.9	3.1	3.7	3.1	3.2
Outer Cape Cod	11.1	23.0	30.3	26.8	22.3
Buzzards Bay	16.0	16.9	32.5	26.6	25.0

Table 28. Percent of females ovigerous by state and region for all American lobster ≥ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	8.5	13.3	18.9	16.2	15.0
Cape Ann	2.5	3.7	9.6	6.3	9.5
Beverly-Salem	2.8	6.3	2.9	1.1	4.8
Boston Harbor	--	--	--	3.2	2.4
Cape Cod Bay	8.0	5.9	7.0	5.5	6.5
Outer Cape Cod	12.9	25.6	34.5	32.2	25.6
Buzzards Bay	17.0	24.6	30.0	28.5	26.6

Table 29. Percent of females ovigerous by state and region for American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	4.3	4.1	6.4	5.1	5.2
Cape Ann	0.0	1.6	1.3	1.2	1.8
Beverly-Salem	1.3	1.5	0.7	0.3	1.1
Boston Harbor	--	--	--	0.7	0.8
Cape Cod Bay	2.2	2.2	2.4	2.0	1.9
Outer Cape Cod	0.0	2.1	1.0	1.4	0.4
Buzzards Bay	15.7	14.2	34.0	25.5	24.3

Table 30. Mean carapace length (mm) of all ovigerous female American lobster by state and region sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	88.5	87.6	88.6	87.4	87.9
Cape Ann	109.0	100.3	94.3	90.5	93.8
Beverly-Salem	80.5	84.5	85.8	83.5	85.9
Boston Harbor	--	--	--	82.1	84.0
Cape Cod Bay	86.4	83.8	85.5	84.4	85.2
Outer Cape Cod	109.8	106.1	108.0	107.1	106.9
Buzzards Bay	78.1	79.6	81.6	83.0	80.1

Table 31. Mean carapace length (mm) of ovigerous female American lobster $\geq$ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	98.2	94.4	94.4	94.0	95.1
Cape Ann	109.0	102.6	96.1	95.0	97.7
Beverly-Salem	89.3	87.8	90.6	90.0	91.0
Boston Harbor	--	--	--	91.0	95.2
Cape Cod Bay	91.9	91.0	91.2	88.9	90.8
Outer Cape Cod	109.8	106.2	108.1	107.4	107.0
Buzzards Bay	84.5	84.7	86.3	91.0	85.6

Table 32. Mean carapace length (mm) of ovigerous female American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	77.3	77.9	77.9	76.4	78.1
Cape Ann	--*	80.0	78.5	79.9	78.8
Beverly-Salem	77.2	77.3	77.8	77.0	78.5
Boston Harbor	--	--	--	70.2	78.3
Cape Cod Bay	77.7	78.4	78.0	77.4	78.5
Outer Cape Cod	--*	77.0	80.0	76.8	74.0
Buzzards Bay	76.9	77.3	77.6	77.4	76.7

*None captured.

Table 33. Percent of ovigerous female American lobster ≥ 81 mm carapace length, by state and region, commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	53.8 (429)*	58.8 (525)	65.0 (1294)	61.4 (885)	57.7 (1294)
Cape Ann	100.0 (2)	90.0 (6)	89.3 (43)	69.9 (36)	79.0 (125)
Beverly-Salem	27.3 (14)	68.6 (24)	62.5 (11)	50.0 (3)	59.1 (80)
Boston Harbor	--	--	--	60.6 (40)	33.8 (60)
Cape Cod Bay	61.0 (192)	42.7 (154)	57.2 (127)	58.1 (81)	54.3 (111)
Outer Cape Cod	100.0 (46)	99.6 (192)	99.7 (476)	99.1 (205)	99.9 (291)
Buzzards Bay	15.4 (175)	30.1 (149)	45.7 (637)	41.2 (520)	38.6 (627)

*(N)

Table 34. Percent of male American lobster, by state and region sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	42.0	41.0	41.0	38.0	41.9
Cape Ann	42.0	46.0	39.0	35.0	41.2
Beverly-Salem	44.0	41.0	51.0	50.0	42.2
Boston Harbor	--	--	--	40.0	48.2
Cape Cod Bay	39.0	36.0	36.0	36.0	40.6
Outer Cape Cod	44.0	46.0	44.0	41.0	45.9
Buzzards Bay	43.0	47.0	36.0	34.0	36.2

Table 35. Percent of male American lobster $\geq$ 81 mm, by state and region, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	44.0	47.0	45.0	41.0	45.6
Cape Ann	47.0	51.0	42.0	36.0	44.8
Beverly-Salem	47.0	49.0	62.0	59.0	44.3
Boston Harbor	--	--	--	45.0	57.6
Cape Cod Bay	43.0	45.0	45.0	43.0	47.2
Outer Cape Cod	43.0	44.0	41.0	41.0	45.3
Buzzards Bay	44.0	48.0	35.0	31.0	32.7

Table 36. Percent of male American lobster < 81 mm, by state and region, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	40.0	37.0	38.0	36.0	39.6
Cape Ann	24.0	30.0	36.0	35.0	38.8
Beverly-Salem	43.0	37.0	47.0	47.0	41.6
Boston Harbor	--	--	--	38.0	44.6
Cape Cod Bay	37.0	33.0	31.0	32.0	37.3
Outer Cape Cod	53.0	54.0	55.0	44.0	49.3
Buzzards Bay	42.0	47.0	37.0	35.0	37.8

Table 37. Cull rate (percent) by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	10.0	10.8	10.7	14.8	18.1
Cape Ann	10.0	9.8	10.5	11.5	23.9
Beverly-Salem	8.3	8.6	10.2	20.9	23.0
Boston Harbor	--	--	--	13.3	19.3
Cape Cod Bay	11.1	10.7	10.9	15.6	18.3
Outer Cape Cod	5.7	11.3	8.9	13.0	13.4
Buzzards Bay	13.5	14.7	12.4	12.4	13.4

Table 38. Cull rate (percent) by state and region for all American lobster ≥ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	8.1	9.7	9.2	12.7	14.8
Cape Ann	10.7	9.6	7.5	10.4	19.4
Beverly-Salem	4.3	7.7	7.4	15.5	19.3
Boston Harbor	--	--	--	10.1	16.2
Cape Cod Bay	9.3	9.3	10.0	13.2	14.5
Outer Cape Cod	5.3	10.3	8.1	13.3	12.5
Buzzards Bay	16.1	13.2	12.7	12.3	13.8

Table 39. Cull rate (percent) by state and region for all marketable American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	8.2	9.9	9.2	15.0	16.2
Cape Ann	10.8	9.8	7.3	11.5	20.9
Beverly-Salem	4.4	8.0	7.4	20.9	18.5
Boston Harbor	--	--	--	13.3	16.2
Cape Cod Bay	9.3	9.3	10.0	15.6	15.9
Outer Cape Cod	5.3	10.9	8.6	14.2	12.9
Buzzards Bay	16.9	13.1	12.3	12.5	15.4

Table 40. Cull rate (percent) by state and region for all American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	11.2	11.5	11.6	16.1	20.2
Cape Ann	8.0	10.6	12.6	12.2	26.9
Beverly-Salem	10.0	9.0	11.2	22.3	24.0
Boston Harbor	--	--	--	14.5	20.5
Cape Cod Bay	11.9	11.3	11.4	17.0	20.2
Outer Cape Cod	7.8	17.9	13.5	11.7	18.6
Buzzards Bay	12.7	15.2	12.2	12.4	13.3

Table 41. Percent trap mortality by state and region for all American lobster sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.15	0.04	0.22	0.15	0.18
Cape Ann	0.00	0.00	0.09	0.27	0.03
Beverly-Salem	0.00	0.00	0.00	0.00	0.04
Boston Harbor	--	--	--	0.00	0.03
Cape Cod Bay	0.00	0.02	0.03	0.00	0.00
Outer Cape Cod	0.46	0.22	0.23	0.48	0.40
Buzzards Bay	0.62	0.00	1.13	0.43	0.76

Table 42. Percent trap mortality by state and region for all American lobster ≥ 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.16	0.04	0.26	0.20	0.23
Cape Ann	0.00	0.00	0.00	0.10	0.03
Beverly-Salem	0.00	0.00	0.00	0.00	0.00
Boston Harbor	--	--	--	0.00	0.04
Cape Cod Bay	0.00	0.00	0.00	0.00	0.00
Outer Cape Cod	0.39	0.16	0.18	0.51	0.36
Buzzards Bay	0.62	0.00	1.46	0.40	0.96

Table 43. Percent trap mortality by state and region for all American lobster < 81 mm, sampled during commercial lobster trap catch survey, Massachusetts coastal waters, 1981-1985.

	1981	1982	1983	1984	1985
State	0.15	0.03	0.20	0.12	0.15
Cape Ann	0.00	0.00	0.14	0.39	0.02
Beverly-Salem	0.00	0.00	0.00	0.00	0.05
Boston Harbor	--	--	--	0.00	0.02
Cape Cod Bay	0.00	0.03	0.05	0.00	0.00
Outer Cape Cod	0.87	0.65	0.50	0.31	0.62
Buzzards Bay	0.62	0.00	0.94	0.45	0.68